M·H

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 20 March 2000 (20.03.00)	
International application No. PCT/SE99/00936	**Applicant's or agent's file reference** 884 /85663
International filing date (day/month/year) 31 May 1999 (31.05.99)	**Priority date** (day/month/year) 24 June 1998 (24.06.98)
Applicant LÖVSÉN, Håkan	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

21 January 2000 (21.01.00)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

Aino Metcalfe

Telephone No.: (41-22) 338.83.38

Copy for the Elected Office (EO/US)

PATENT COOPERATION TREATY

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

From the INTERNATIONAL BUREAU

To:

BERGQUIST, Gunnar
Albihns Patentbyra Göteborg AB
P.O. Box 142
Torggatan 8
S-401 22 Göteborg
SUÈDE

Date of mailing (day/month/year)
05 July 2000 (05.07.00)

IMPORTANT NOTIFICATION

Applicant's or agent's file reference
884 /85663

International application No.
PCT/SE99/00936

International filing date (day/month/year)
31 May 1999 (31.05.99)

1. The following indications appeared on record concerning:

☐ the applicant ☐ the inventor ☒ the agent ☐ the common representative

Name and Address
LUNDMARK, Jan-Erik
Saab AB
Patent Dept.
S-581 88 Linköping
Sweden

State of Nationality:
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Facsimile No.: 013 187 195
Teleprinter No.:

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

☒ the person ☐ the name ☐ the address ☐ the nationality ☐ the residence

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BERGQUIST, Gunnar
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State of Nationality:
State of Residence:
Telephone No.:
Facsimile No.:
Teleprinter No.:

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

☒ the receiving Office
☐ the International Searching Authority
☐ the International Preliminary Examining Authority
☐ the designated Offices concerned
☒ the elected Offices concerned
☒ other: Former agent

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer
Beatriz Morariu

Telephone No.: (41-22) 338.83.38

003392696

Form PCT/IB/306 (March 1994)

TENT COOPERATION TREA

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

BERGQUIST, Gunnar
Albihns Patentbyra Göteborg AB
P.O. Box 142
Torggatan 8
S-401 22 Göteborg
SUÈDE

Date of mailing (day/month/year)	
05 July 2000 (05.07.00)	
Applicant's or agent's file reference	**IMPORTANT NOTIFICATION**
884 /85663	
International application No.	**International filing date** (day/month/year)
PCT/SE99/00936	31 May 1999 (31.05.99)

1. The following indications appeared on record concerning:

[X] the applicant [ ] the inventor [ ] the agent [ ] the common representative

Name and Address	State of Nationality	State of Residence
COMBITECH TRAFFIC SYSTEMS AB P.O. Box 1063 S-551 10 Jönköping Sweden	SE	SE
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[X] the person [X] the name [X] the address [X] the nationality [X] the residence

Name and Address	State of Nationality	State of Residence
KAPSCH AKTENGESELLSCHAFT Wanganseilgasse 1 A-1121 Wien Austria	AT	AT
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

3. Further observations, if necessary:
Transfer of rights

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[ ] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[X] the elected Offices concerned
[ ] other:

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer Beatriz Morariu
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

TENT COOPERATION TREA

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

From the INTERNATIONAL BUREAU

To:

BERGQUIST, Gunnar
Albihns Patentbyra Göteborg AB
P.O. Box 142
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SUÈDE

Date of mailing (day/month/year)
25 August 2000 (25.08.00)

Applicant's or agent's file reference
884 /85663

IMPORTANT NOTIFICATION

International application No.
PCT/SE99/00936

International filing date (day/month/year)
31 May 1999 (31.05.99)

1. The following indications appeared on record concerning:

[X] the applicant [ ] the inventor [ ] the agent [ ] the common representative

Name and Address

COMBITECH TRAFFIC SYSTEMS AB
P.O. Box 1063
S-551 10 Jönköping
Sweden

State of Nationality: SE
State of Residence: SE
Telephone No.:
Facsimile No.:
Teleprinter No.:

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[X] the person [ ] the name [ ] the address [ ] the nationality [ ] the residence

Name and Address

State of Nationality:
State of Residence:
Telephone No.:
Facsimile No.:
Teleprinter No.:

3. Further observations, if necessary:
The applicant remains as indicated in box 1. Our form IB/306 of 05 July 2000 should be considered as null and void

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[ ] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[X] the elected Offices concerned
[ ] other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No.: (41-22) 740.14.35

Authorized officer
Beatriz Morariu
Telephone No.: (41-22) 338.83.38

RECORD COPY

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No. PCT/ SE 99/ 00936

International Filing Date 31 -05- 1999

The Swedish Patent Office
PCT International Application

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* 884 /85663

Box No. I TITLE OF INVENTION

DEVICE FOR POSITION BY MEANS OF DETERMINATION WITH RADIOWAVES

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

COMBITECH TRAFFIC SYSTEMS AB
Box 1063
S-551 10 JÖNKÖPING
Sweden

☐ This person is also inventor.

Telephone No. 036-194300

Facsimile No. 036-194301

Teleprinter No.

State *(that is, country)* of nationality: Sweden

State *(that is, country)* of residence: Sweden

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

Lövsén, Håkan
Ektunavägen 89
S-589 33 LINKÖPING
SWEDEN

This person is:

☐ applicant only

☒ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: Sweden

State *(that is, country)* of residence: Sweden

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

Lundmark, Jan-Erik
SAAB AB
Patent Department
S-581 88 LINKÖPING
Sweden

Telephone No. 013 18 71 97

Facsimile No. 013 18 71 95

Teleprinter No.

☐ **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Box No.V DESIGNATION OF STATES 31 -05- 1999

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked)*:

Regional Patent

- ☐ **AP** **ARIPO Patent:** **GH** Ghana, **GM** Gambia, **KE** Kenya, **LS** Lesotho, **MW** Malawi, **SD** Sudan, **SZ** Swaziland, **UG** Uganda, **ZW** Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT
- ☐ **EA** **Eurasian Patent:** **AM** Armenia, **AZ** Azerbaijan, **BY** Belarus, **KG** Kyrgyzstan, **KZ** Kazakhstan, **MD** Republic of Moldova, **RU** Russian Federation, **TJ** Tajikistan, **TM** Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- ☒ **EP** **European Patent:** **AT** Austria, **BE** Belgium, **CH and LI** Switzerland and Liechtenstein, **CY** Cyprus, **DE** Germany, **DK** Denmark, **ES** Spain, **FI** Finland, **FR** France, **GB** United Kingdom, **GR** Greece, **IE** Ireland, **IT** Italy, **LU** Luxembourg, **MC** Monaco, **NL** Netherlands, **PT** Portugal, **SE** Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- ☐ **OA** **OAPI Patent:** **BF** Burkina Faso, **BJ** Benin, **CF** Central African Republic, **CG** Congo, **CI** Côte d'Ivoire, **CM** Cameroon, **GA** Gabon, **GN** Guinea, **ML** Mali, **MR** Mauritania, **NE** Niger, **SN** Senegal, **TD** Chad, **TG** Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

National Patent *(if other kind of protection or treatment desired, specify on dotted line)*:

- ☐ **AL** Albania .....
- ☐ **AM** Armenia .....
- ☐ **AT** Austria .....
- ☒ **AU** Australia .....
- ☐ **AZ** Azerbaijan
- ☐ **BA** Bosnia and Herzegovina .....
- ☐ **BB** Barbados
- ☐ **BG** Bulgaria .....
- ☒ **BR** Brazil .....
- ☐ **BY** Belarus .....
- ☐ **CA** Canada
- ☐ **CH and LI** Switzerland and Liechtenstein
- ☒ **CN** China .....
- ☐ **CU** Cuba .....
- ☐ **CZ** Czech Republic .....
- ☐ **DE** Germany .....
- ☐ **DK** Denmark .....
- ☐ **EE** Estonia .....
- ☐ **ES** Spain .....
- ☐ **FI** Finland .....
- ☐ **GB** United Kingdom
- ☐ **GE** Georgia .....
- ☐ **GH** Ghana .....
- ☐ **GM** Gambia
- ☐ **GW** Guinea-Bissau .....
- ☐ **HR** Croatia
- ☐ **HU** Hungary .....
- ☐ **ID** Indonesia
- ☐ **IL** Israel .....
- ☐ **IS** Iceland
- ☐ **JP** Japan .....
- ☐ **KE** Kenya .....
- ☐ **KG** Kyrgyzstan .....
- ☐ **KP** Democratic People's Republic of Korea .....
- ☒ **KR** Republic of Korea .....
- ☐ **KZ** Kazakhstan .....
- ☐ **LC** Saint Lucia
- ☐ **LK** Sri Lanka
- ☐ **LR** Liberia
- ☐ **LS** Lesotho .....
- ☐ **LT** Lithuania
- ☐ **LU** Luxembourg
- ☐ **LV** Latvia
- ☐ **MD** Republic of Moldova .....
- ☐ **MG** Madagascar .....
- ☐ **MK** The former Yugoslav Republic of Macedonia .....
- ☐ **MN** Mongolia
- ☐ **MW** Malawi .....
- ☐ **MX** Mexico .....
- ☒ **NO** Norway
- ☐ **NZ** New Zealand .....
- ☐ **PL** Poland .....
- ☐ **PT** Portugal .....
- ☐ **RO** Romania
- ☐ **RU** Russian Federation .....
- ☐ **SD** Sudan
- ☐ **SE** Sweden
- ☒ **SG** Singapore
- ☐ **SI** Slovenia .....
- ☐ **SK** Slovakia .....
- ☐ **SL** Sierra Leone
- ☐ **TJ** Tajikistan .....
- ☐ **TM** Turkmenistan .....
- ☐ **TR** Turkey .....
- ☐ **TT** Trinidad and Tobago .....
- ☐ **UA** Ukraine .....
- ☐ **UG** Uganda .....
- ☒ **US** United States of America .....
- ☐ **UZ** Uzbekistan .....
- ☐ **VN** Viet Nam .....
- ☐ **YU** Yugoslavia .....
- ☐ **ZW** Zimbabwe .....

Check-boxes reserved for designating States (for the purposes of a national patent) which have become party to the PCT after issuance of this sheet:

- ☐ .....
- ☐ .....

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)*

Box No. VI PRIORITY CLAIM ☐ Further priority claims are indicated in the Supplemental Box.

Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is: national application: country	regional application:* regional Office	international application: receiving Office
item (1) 24 June 1998 24/06/98	SE 9802234-6	Sweden		
item (2)				
item (3)				

☒ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office)* identified above as item(s): (1)

** Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.*

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used)*: ISA / SE

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority)*:

Date (day/month/year)	Number	Country (or regional Office)
24.06.1998	SE/1998/00820	SE

Box No. VIII CHECK LIST; LANGUAGE OF FILING

RD/SE

This international application contains the following **number of sheets**:

request	: 3
description (excluding sequence listing part)	: 15
claims	: 2
abstract	: 1
drawings	: 2
sequence listing part of description	:
Total number of sheets	: 23

This international application is **accompanied by** the item(s) marked below:

1. ☐ fee calculation sheet
2. ☐ separate signed power of attorney
3. ☒ copy of general power of attorney; reference number, if any:
4. ☐ statement explaining lack of signature
5. ☐ priority document(s) identified in Box No. VI as item(s):
6. ☐ translation of international application into (language):
7. ☐ separate indications concerning deposited microorganism or other biological material
8. ☐ nucleotide and/or amino acid sequence listing in computer readable form
9. ☐ other *(specify)*:

Figure of the drawings which should accompany the abstract: Fig. 3

Language of filing of the international application: Swedish

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

Linköping, May 28, 1999

Jan-Erik Lundmark

For receiving Office use only

1. Date of actual receipt of the purported international application: 31-05-1999	2. Drawings: ☒ received: ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:	
4. Date of timely receipt of the required corrections under PCT Article 11(2):	
5. International Searching Authority (if two or more are competent): ISA / SE	6. ☐ Transmittal of search copy delayed until search fee is paid.

For International Bureau use only

Date of receipt of the record copy by the International Bureau: 09 AUGUST 1999 09.08.99

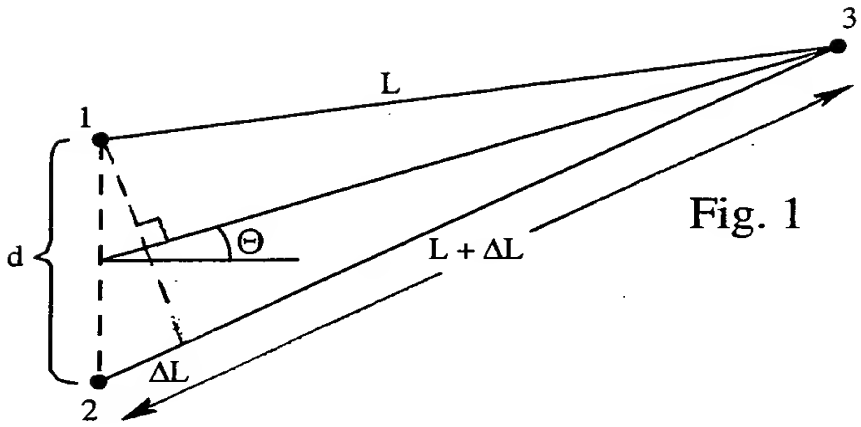


Fig. 1

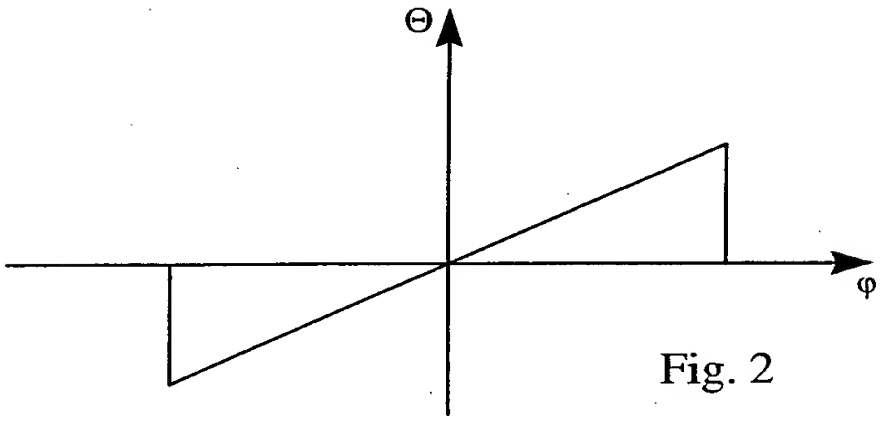


Fig. 2

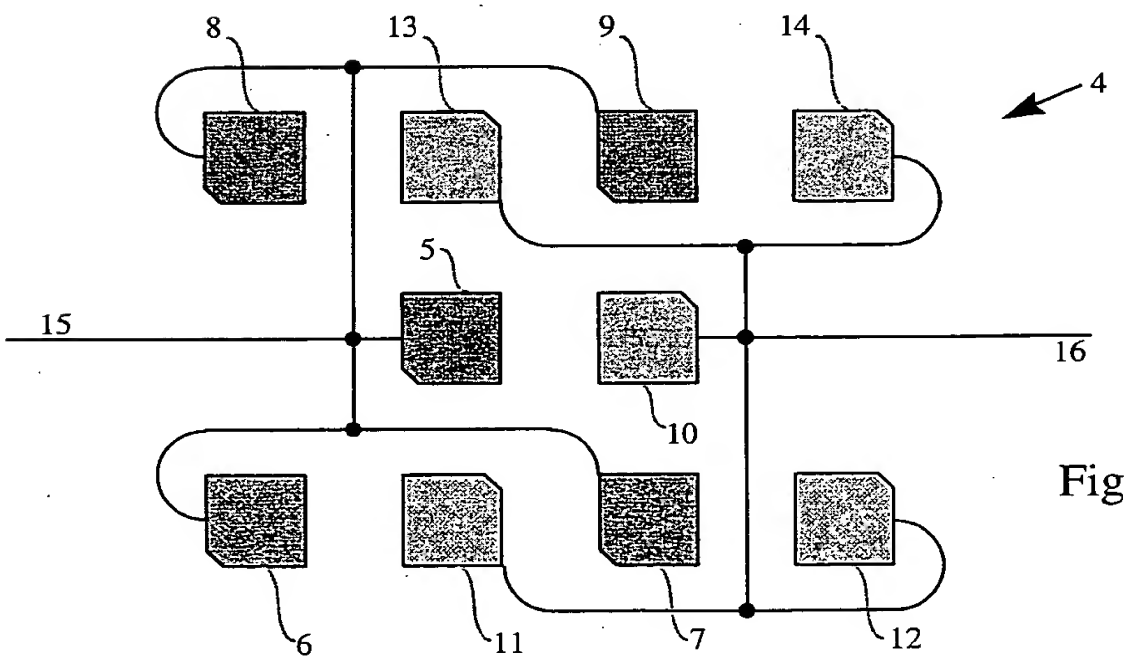


Fig. 3

Fig. 4

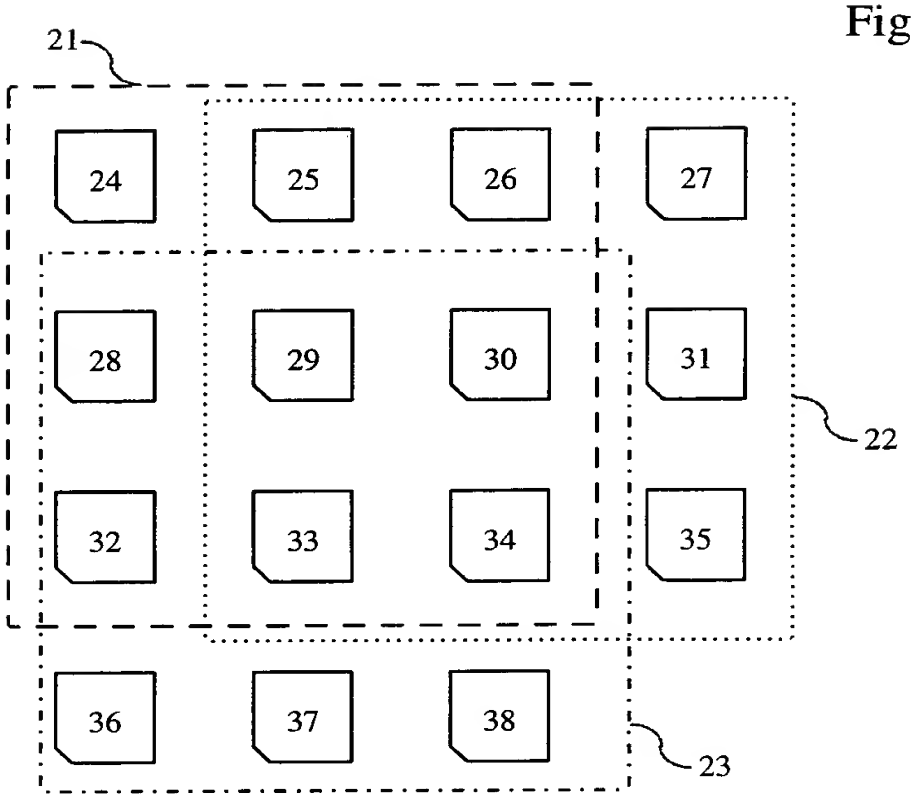
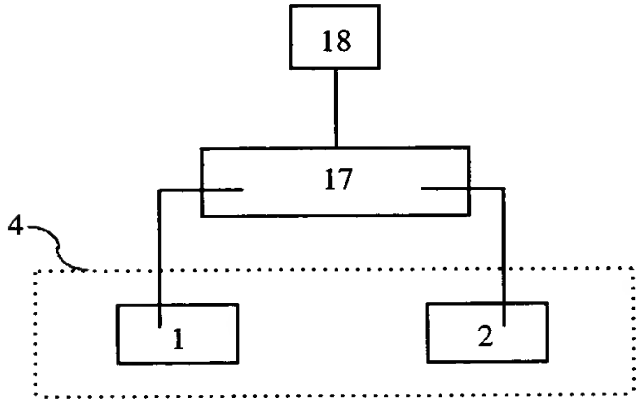


Fig. 5



31 -05- 1999

Anordning för positionsbestämning medelst radiovågor.

TEKNISKT OMRÅDE

Uppfinningen avser en anordning för positionsbestämning medelst radiovågor, företrädesvis mikrovågor. Särskilt avses successiv positionsbestämning av fordon på en vägbana.

TEKNIKENS STÅNDPUNKT

Vid en metod för positionsbestämning m h a radiovågor, s k inmätning, utsänds en radiosignal, företrädesvis inom mikrovågsområdet, där signalen har god riktverkan och egenskapen att reflekteras från föremål, alternativt återutsändas med härför avsedd anordning. Den reflekterade signalen mottas med två antenner, vilka är arrangerade så att de är distanserade från varandra i ett plan huvudsakligen vinkelrätt mot riktningen till föremålet. Genom avståndet mellan antennerna kommer en av föremålet reflekterad våg att få en längre färdsträcka till den ena antennen än till den andra. Denna skillnad i tillryggalagd sträcka ger upphov till en fasskillnad mellan de mottagna signalerna. Ur fasskillnaden kan en referensvinkel till föremålet i förhållande till antennerna beräknas i ett plan som bildas av antenner och föremål. Ett sådant förfarande beskrivs t ex i svenska patentansökan nr 8403564-1. På detta sätt svarar varje position hos föremålet mot en viss fasskillnad.

Metoden visas geometriskt i figur 1. Antennerna 1 och 2 är placerade på ett avstånd d från varandra. Föremålet 3, eller vanligtvis en s k transponder på detta föremål, vars position ska bestämmas, reflekterar den utsända vågen i riktning mot antennerna 1 och 2. Genom att antennerna är distanserade avståndet d från varandra, uppkommer en skillnad ΔL i tillryggalagd sträcka. Skillnaden ΔL ger upphov till en fasskillnad $\Delta\varphi =$

$\varphi_1 - \varphi_2$, där φ_1 och φ_2 är fasvinkeln för den mottagna signalen vid antennerna 1 respektive 2. Ur denna fasskillnad $\Delta\varphi$ kan den geometriska vinkeln θ beräknas, sin $\theta \propto \Delta L \propto \Delta\varphi$.

Vinkeln θ är således periodiskt beroende av fasskillnaden $\Delta\varphi$, såsom framgår av figur 2. Detta innebär att det finns ett intervall utanför vilket vinkeln θ inte längre är entydig, utan kan svara mot mer än en position. Detta intervall är omvänt beroende av avståndet d, d v s intervallet ökar då d minskar. Man önskar således ur denna synvinkel ha ett så litet avstånd d som möjligt för att uppnå ett stort entydighetsområde för vinkeln θ.

För att uppnå god riktverkan i en antenn byggs denna upp av flera antennelement, för att bilda s k gruppantenner. Ett sådant arrangemang ger naturligtvis antennerna en viss fysisk utbredning och begränsar därmed avståndet d nedåt. Avståndet d i figur 1 avser för ett par av gruppantenner avståndet mellan respektive antenncentrum.

Kravet på god riktverkan står därmed i konflikt med kravet på stort entydighetsområde. Uppfinningen anger en anordning för att uppfylla kravet på god riktverkan samtidigt som kravet på stort entydighetsområde upprätthålls.

REDOGÖRELSE FÖR UPPFINNINGEN

Uppfinningen är inriktad mot att uppnå ett litet avstånd mellan minst två gruppantennrs centrum och ändå medge en stor utbredning för respektive gruppantenn för att medge både god riktverkan och ett stort entydighetsområde. Detta åstadkoms enligt uppfinningsaspekten genom att antennelement hos gruppantennerna inväves i varandra på ett sådant sätt att antenncentrum för gruppantennerna befinner sig på ett inbördes litet avstånd. Detta åstadkoms enligt uppfinningen genom koppling av de olika antennelementen i gruppantennerna, så att de centrala antennelementen i respektive gruppantenn är inrättade att ligga nära varandra.

31 -05- 1999

FIGURBESKRIVNING

Figur 1 och 2 hänför sig till uppfinningens grundprinciper och har beskrivits ovan såsom känd teknik, medan figur 3, 4 och 5 hänför sig till en aspekt av uppfinningen.

Figur 1 visar en schematisk bild av en mätprincip där fasskillnaden mellan två i antenner mottagna signaler analyseras för positionsbestämning av ett föremål genom vinkelmätning med antennerna placerade på ett bestämt avstånd från varandra.

Figur 2 återger den geometriska vinkelavvikelsen för föremålet som funktion av fasskillnaden.

Figur 3 visar ett antennarrangemang enligt uppfinningen i frontal vy.

Figur 4 visar ett alternativt antennarrangemang enligt uppfinningen.

Figur 5 visar ett blockschema för en inmätningsanordning som nyttjar ett antennarrangemang enligt uppfinningsaspekten.

UTFÖRINGSFORMER

I figur 5 visas en anordning för positionsbestämning av ett föremål som färdas längs en bana. Anordningen innefattar en förstärkar- och signalbehandlingsenhet 17 ansluten till en signalprocessor 18 och ett antennarrangemang 4 med två gruppantenner 1 och 2, där gruppantennerna är ordnade längs en första axel vinkelrät mot föremålets färdriktning. Antennarrangemanget består av två grupper av ledande ytor, antennelement, enligt figur 3. Gruppantennen 1 bildas av de fem ytorna, antennelementen, 5 – 9 på ett sådant sätt att antennelementen 6 – 9 är placerade perifert kring det centrala antennelementet 5. På samma sätt bildas gruppantenn 2 av det centrala antennelementet 10 och de perifera antennelementen 11 – 14. Genom de utgående ledningarna 15 och 16 binds antennelementen inom respektive grupp samman så att de bildar de två gruppantennerna 1 och 2. Genom det beskrivna arrangemanget symmetriskt anordnat kring de centrala antennelementen 5 resp 10, bildar dessa centrala ytor i form av

antennelement respektive gruppantenns fascentrum. Avståndet mellan dessa båda fascentrum utgör således avståndet d i figur 1.

Antennens 1 bredd sträcker sig från vänstra kanten av antennelementen 6 och 8 till högra kanten av antennelementen 7 och 9. Bredden för antennen 2 sträcker sig från vänstra kanten av antennelementen 11 och 13 till högra kanten av antennelementen 12 och 14. Om antennerna lades sida vid sida skulle detta innebära att avståndet d mellan respektive fascentrum 5 och 10 skulle bli minst lika stort som en gruppantenns totala bredd, och i praktiken mer eftersom det måste finnas en viss distans mellan de yttersta antennelementen i resp gruppantenn 1, 2. Som framgår av figur 3 så är emellertid avståndet mellan fascentrum betydligt mindre, vilket således åstadkommits genom att de olika antennelementen kopplats, i denna utföringsform genom att låta gruppantennerna vara invävda i varandra.

Den beskrivna principen kan utnyttjas även i mer komplicerade antennarrangemang. Således kan vinkelmätning förfinas genom att fler än två antenner placeras i ett sådant arrangemang, dvs med antennerna ordnade längs den första axeln. Mätnoggrannheten förbättras naturligtvis om man kan medelvärdesbilda över ett stort antal mätresultat.

En annan fördel med att använda mer än två gruppantenner inrättade på samma axel ges av följande. Om avståndet d mellan två gruppantenners centrum ökas, innebär detta att sträckan ΔL ökar för varje vinkel θ. Om sträckan ΔL ökas medför detta en ökad fasskillnad $\Delta\varphi$ för varje vinkeländring, dvs upplösningen förbättras. Återigen kommer detta i konflikt med kravet på entydighet. Genom att inrätta flera gruppantenner i rad på samma axel, t ex tre antenner benämnda A, B och C i nämnd ordning kan den beskrivna konflikten lösas. Genom att använda den uppmätta fasskillnaden ur data erhållna från antennerna A och B för entydigheten och den uppmätta fasskillnaden mellan antennerna A och C för att erhålla en bättre upplösning kan båda önskemålen tillgodoses.

Det är även möjligt att anordna antenner utefter flera axlar och därigenom medge inmätning i flera plan. Genom att placera ytterligare minst ett par gruppantenner längs

en axel i huvudsak vinkelrät mot den första axeln och i huvudsak vinkelrätt mot föremålets färdriktning, så kan således en referensvinkel till föremålet i förhållande till antennerna bestämmas i vardera av de två mot varandra huvudsakligen vinkelräta plan som bildas av föremålet och respektive axel på vilken antennpar är ordnade. Om föremålet som ett exempel utgörs av ett fordon som färdas på en vägbana, där gruppantenner anordnats längs en horisontell första axel på en sådan höjd över vägbanan att fordon kan passera under antennerna definieras ett i huvudsak horisontellt första plan genom antennerna 1, 2 och fordonet 3. I detta horisontella plan kan härvid en azimutvinkel θ till fordonet bestämmas, som beskrivits, genom bestämning av fasvinkeln φ. Genom att inrätta gruppantenner längs en andra axel som är vinkelrät mot den första axeln och i huvudsak vinkelrät mot vägbanan blir det på motsvarande sätt möjligt att bestämma en elevationsvinkel till fordonet, där elevationsvinkeln refererar till den lodräta andra axeln. Via kännedom om både azimut- och elevationsvinkeln sett från de båda uppsättningarna av antenner bestämmes ur dessa vinklar fordonets position i förhållande till antennerna

En alternativ utföringsform med koppling enligt uppfinningen mellan de olika delytorna uppkommer genom att vissa antennelement anordnas att ingå i två eller flera gruppantenner. Utföringsformen beskrivs schematiskt i figur 4 för fallet med inmätning i två dimensioner. I detta fall utgörs antennen 20 av minst 3 gruppantenner. Gruppantennen 21 utgörs av antennelementen 24 – 26, 28 – 30 och 32 – 34, där 29 utgör fascentrum. Gruppantennen 22 utgörs av antennelementen 25 – 27, 29 – 31, och 33 - 35, med 30 som fascentrum. Gruppantenn 23 utgörs av antennelementen 28 – 30, 32 – 34 och 36 – 38, med 33 som fascentrum. Således används flera antennelement av fler än en gruppantenn. Detta låter sig göras genom effektförstärkning av de mottagna signalerna från åtminstone dessa antennelement och därefter tillämpa effektdelning på den förstärkta signalen. I denna utförandeform erhålls samma korta avstånd d som i den tidigare utföringsformen.

31 -05- 1999

PATENTKRAV

1. Anordning vid bestämning av ett fordons position på en bana genom användning av radiovågor som utsänds från anordningen och reflekteras av fordonet och mottas av minst två gruppantenner (1, 2) anordnade tvärs banan, **kännetecknad av** att gruppantennerna (1, 2) innefattar ett antal antennelement (5 - 14), varav ett av antennelementen i respektive gruppantenn utgör gruppantennernas fascentrum (5, 10) och där gruppantennernas antennelement (5 - 14) är kopplade till varandra så att avståndet (d) mellan fascentrum (5, 10) för de ingående gruppantennerna (1, 2) är mindre än en enskild gruppantenns (1, 2) halva bredd.

2. Anordning enligt patentkrav 1, **kännetecknad av** att kopplingen består i att gruppantennerna (1, 2) är invävda i varandra, genom att en gruppantenns fascentrum (5, 10) är anordnad inne bland en annan gruppantenns (1, 2) antennelement (11 - 14, 6 - 9).

3. Anordning enligt patentkrav 2, **kännetecknad av** att respektive gruppantenns (1, 2) fascentrum (5, 10) är placerade intill varandra.

4. Anordning enligt patentkrav 2, **kännetecknad av** att vissa av antennelementen (24 - 38) samtidigt är kopplade till mer än en gruppantenn (21, 22, 23).

5. Anordning enligt patentkrav 4, **kännetecknad av** att signaler erhållna från antennelement (24 - 38) som utnyttjas av mer än en gruppantenn (21, 22, 23) effektförstärks, varefter den förstärkta signalen effektdelas på resp gruppantenn (21, 22, 23).

6. Anordning enligt något av föregående patentkrav, **kännetecknad av** att en azimutvinkel θ till fordonet (3) bestämmes från en antennposition där minst ett par huvudsakligen horisontellt inrättade gruppantenner (1, 2) anordnats.

7. Anordning enligt patentkrav 6, **kännetecknad av** att en elevationsvinkel till fordonet (3) bestämmes från en antennposition där minst ett par huvudsakligen lodrätt inrättade gruppantenner anordnats.

8. Anordning enligt patentkrav 7, **kännetecknad av** att fordonets position i förhållande till antennerna bestämmes via kännedom om azimutvinkeln θ och elevationsvinkeln.

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SAMMANDRAG

En anordning vid bestämning av ett fordons position på en bana genom användning av radiovågor som utsänds från anordningen och reflekteras av fordonet och mottas av minst två gruppantenner (1, 2) anordnade tvärs banan, där gruppantennerna (1, 2) innefattar ett antal antennelement (5 - 14), varav ett av antennelementen i respektive gruppantenn utgör gruppantennernas fascentrum (5, 10) och där gruppantennernas antennelement (5 - 14) är kopplade till varandra så att avståndet (d) mellan fascentrum (5, 10) för de ingående gruppantennerna (1, 2) är mindre än en enskild gruppantenns (1, 2) halva bredd. (Fig. 3).

PATENT COOPERATION TREATY

PCT

7

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 884	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/SE99/00936	International filing date *(day/month/year)* 31.05.1999	Priority date *(day/month/year)* 24.06.1998
International Patent Classification (IPC) or national classification and IPC G01S 13/42, G01S 13/74		
Applicant COMBITECH TRAFFIC SYSTEMS AB ET AL.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

   ☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of _____ sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
21.01.2000	13.06.2000
Name and mailing address of the IPEA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. 08-667 72 88 Telex 17978 PATOREG-S	Authorized officer Göran Magnusson/AE Telephone No. 08-782 25 00

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/SE99/00936

I. Basis of the report

1. This report has been drawn on the basis of *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.)*:

☒ the international application as originally filed.

☐ the description, pages _____ , as originally filed,
pages _____ , filed with the demand,
pages _____ , filed with the letter of _____ .
pages _____ , filed with the letter of _____ .

☐ the claims, Nos. _____ , as originally filed,
Nos. _____ , as amended under Article 19,
Nos. _____ , filed with the demand,
Nos. _____ , filed with the letter of _____ ,
Nos. _____ , filed with the letter of _____ .

☐ the drawings, ~~sheets~~/fig _____ , as originally filed,
~~sheets~~/fig _____ , filed with the demand
~~sheets~~/fig _____ , filed with the letter of _____ ,
~~sheets~~/fig _____ , filed with the letter of _____ .

2. The amendments have resulted in the cancellation of:

☐ the description, pages _____
☐ the claims, Nos. _____
☐ the drawings, ~~sheets~~/fig _____

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the supplemental Box (Rule 70.2(c)).

4. Additional observations, if necessary:

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/SE99/00936

V. Resoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-8	YES
	Claims		NO
Inventive step (IS)	Claims	1-8	YES
	Claims		NO
Industrial applicability (IA)	Claims	1-8	YES
	Claims		NO

2. Citations and explanations

The claimed invention relates to a device for determining the position of a vehicle by using radio waves, which are emitted from the device and reflected by the vehicle and received by two array antennas. The problem is to achieve a small distance between the array antennas. According to the invention the array antennas are interleaved such that the distance between the phase centres of the array antennas is smaller than half the width of an individual array antenna.

During the international search the following documents were found:
D1 : WO 8600716 A1
D2 : WO 9219021 A1
D3 : US 5546095 A

The documents cited as category Y in the search report are reconsidered.

D1 discloses a device for determining the position of a vehicle comprising two array antennas for measuring the phase difference between reflected signals (see figures 1 and 4).

D2 discloses at least two interleaved array antennas. The distance between the phase centres of the array antennas is smaller than half the width of an individual array antenna (see page 5, lines 20-33, figure 3).

D3 discloses two interleaved array antennas with some of the antenna elements connected to both antennas. The distance between the phase centres of the array antennas is equal to half the width of an individual array antenna (see figures 1 and 2).

.../...

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: BOX V.

However, the need of decreasing the distance between the phase centres of the antennas is not discussed in D1 and use of interleaved array antennas for determining position by phase measurements is not suggested in D2. Therefore, it is not considered obvious to a person skilled in the art to arrive at a device according to claim 1 by combining documents D1 and D2.

The invention claimed in claims 1-8 is considered to be novel (N), to involve an inventive step (IS) and also to have industrial applicability (IA).

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G01S 13/42, 13/74

A1

(11) International Publication Number: **WO 99/67655**

(43) International Publication Date: 29 December 1999 (29.12.99)

(21) International Application Number: PCT/SE99/00936

(22) International Filing Date: 31 May 1999 (31.05.99)

(30) Priority Data:
9802234-6 24 June 1998 (24.06.98) SE

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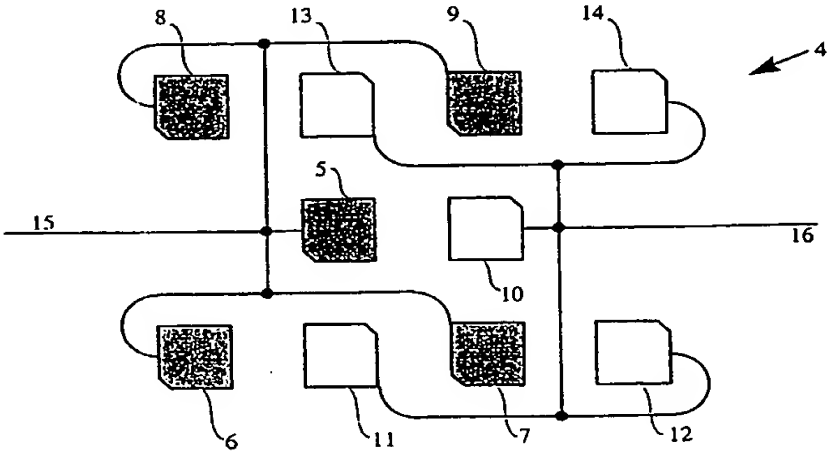
(81) Designated States: AU, BR, CN, KR, NO, SG, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.
In English translation (filed in Swedish).

(54) Title: DEVICE FOR POSITION DETERMINATION BY MEANS OF RADIO WAVES



(57) Abstract

A device for determining the position of a vehicle on a roadway by using radio waves which are emitted from the device and reflected by the vehicle and received by at least two array antennas (1, 2) arranged across the roadway, wherein the array antennas (1, 2) comprise a number of antenna elements (5–14), one of the antenna elements in the respective array antenna constituting the phase center (5, 10) of the array antennas, and wherein the antenna elements (5–14) of the array antennas are connected to one another such that the distance (d) between the phase centers (5, 10) of the array antennas (1, 2) included is smaller than half the width of an individual array antenna (1, 2).

DEVICE FOR POSITION DETERMINATION BY MEANS OF RADIO WAVES

TECHNICAL FIELD

The invention relates to a device for position determination by means of radio waves, preferably microwaves. In particular, it relates to successive position determination of vehicles on a roadway.

BACKGROUND ART

In a method for position determination by means of radio waves, so-called measuring in, a radio signal is emitted, preferably within the microwave range, where the signal has good directivity and the property of being reflected from objects, or, alternatively, of being reemitted with a device intended therefor. The reflected signal is received with two antennas, which are arranged so as to be at a distance from each other in a plane substantially perpendicular to the direction to the object. By the distance between the antennas, a wave reflected by the object will have a longer distance of travel to one of the antennas than to the other. This difference in the distance covered gives rise to a phase difference between the received signals. From the phase difference, a reference angle to the object in relation to the antennas may be calculated in a plane which is formed by antennas and object. Such a method is described, for example, in Swedish patent application No. 8403564-1. In this way, each position of the object corresponds to a certain phase difference.

The method is shown geometrically in Figure 1. The antennas 1 and 2 are placed at a distance d from each other. The object 3, or usually a so-called transponder on this object, the position of which is to be determined, reflects the emitted wave in a direction towards the antennas 1 and 2. Because the antennas are spaced at the distance d from each other, a difference ΔL in the distance covered arises. The difference ΔL gives rise to a

phase difference $\Delta\varphi = \varphi_1 - \varphi_2$, where φ_1 and φ_2 are the phase angle for the signal received at the antennas 1 and 2, respectively. From this phase difference $\Delta\varphi$, the geometrical angle θ may be calculated, $\sin\theta \propto \Delta L \propto \Delta\varphi$.

The angle θ is thus periodically dependent on the phase difference $\Delta\varphi$, as is clear from Figure 2. This means that there is an interval outside of which the angle θ is no longer unambiguous but may correspond to more than one position. This interval is inversely dependent on the distance d, that is, the interval increases when d decreases. Thus, from this point of view, it is desired to have as small a distance d as possible to achieve a large unambiguous region for the angle θ.

To achieve good directivity in an antenna, it is composed of a plurality of antenna elements to form so-called array antennas. Such an arrangement, of course, gives the antennas a certain physical extent and thus limits the distance d downward. The distance d in Figure 1 relates, for a pair of array antennas, to the distance between the respective antenna centers.

Hence, the requirement for good directivity conflicts with the requirement for a large unambiguous region. The invention suggests a device for satisfying the requirement for good directivity while at the same time maintaining the requirement for a large unambiguous region.

SUMMARY OF THE INVENTION

The invention is directed towards achieving a small distance between the centers of at least two array antennas while still allowing a large extent for the respective array antenna in order to permit both good directivity and a large unambiguous region. This is achieved according to the aspect of the invention by interweaving antenna elements of the array antennas with

one another in such a way that the antenna centers for the array antennas are at a small mutual distance. This is achieved according to the invention by connecting the various antenna elements in the array antennas such that the central antenna elements in the respective array antenna are arranged close to one another.

BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1 and 2 relate to the basic principles of the invention and are described above as prior art, whereas Figures 3, 4 and 5 relate to one aspect of the invention.

Figure 1 is a schematic picture of a principle of measurement in which the phase difference between two signals received in antennas are analyzed for position determination of an object by angular measurement with the antennas placed at a definite distance from one another,

Figure 2 illustrates the geometrical angular deviation for the object as a function of the phase difference,

Figure 3 shows an antenna arrangement according to the invention in a frontal view,

Figure 4 shows an alternative antenna arrangement according to the invention,

Figure 5 shows a block diagram for a device for measuring in, which utilizes an antenna arrangement according to the aspect of the invention.

DESCRIPTION OF EMBODIMENTS

Figure 5 shows a device for position determination of an object which travels along a path. The device comprises an amplification and signal-processing unit 17 connected to a signal processor 18 and an antenna arrangement 4 with two array antennas 1 and 2, the array antennas being arranged along a first axis perpendicular to the direction of travel of the object. The antenna arrangement comprises two arrays of conducting surfaces, antenna elements,

according to Figure 3. The array antenna 1 is formed of the five surfaces, antenna elements, 5-9 in such a way that the antenna elements 6-9 are placed peripherally around the central antenna element 5. In the same way, array antenna 2 is formed of the central antenna element 10 and the peripheral antenna elements 11-14. Through the output conductors 15 and 16, the antenna elements within the respective array are joined together to form the two array antennas 1 and 2. By means of the arrangement described, symmetrically arranged around the central antenna elements 5 and 10, respectively, these central surfaces, in the form of antenna elements, form the phase center of the respective array antenna. The distance between these two phase centers thus constitutes the distance d in Figure 1.

The width of the antenna 1 extends from the lefthand edge of the antenna elements 6 and 8 to the righthand edge of the antenna elements 7 and 9. The width of the antenna 2 extends from the lefthand edge of the antenna elements 11 and 13 to the righthand edge of the antenna elements 12 and 14. If the antennas were placed side by side, this would mean that the distance d between the respective phase centers 5 and 10 would become at least as large as the total width of an array antenna, and in practice more since there has to be a certain distance between the outermost antenna elements in the respective array antenna 1, 2. As is clear from Figure 3, however, the distance between the phase centers is considerably smaller, which thus is achieved by interconnecting the various antenna elements, in this embodiment by allowing the array antennas to be interwoven with one another.

The principle described may be utilized also in more complicated antenna arrangements. Thus, angle measurement may be refined by placing more than two antennas in such an arrangement, that is, with the antennas arranged along the first axis. The accuracy of measurement is, of course,

improved if it is possible to form the mean value over a large number of measurement results.

Another advantage of using more than two array antennas aligned on the same axis is given by the following. If the distance d between the centers of two array antennas increases, this implies that the distance ΔL increases for each angle θ. If the distance ΔL is increased, this implies an increased phase difference $\Delta\varphi$ for each change of angle, that is, the resolution is improved. Again, this comes into conflict with the requirement for unambiguity. By arranging a plurality of array antennas in a row on the same axis, for example, three antennas designated A, B and C in the mentioned order, the described conflict may be solved. By using the measured phase difference from data obtained from antennas A and B for the unambiguity and the measured phase difference between antennas A and C for obtaining an improved resolution, both requirements may be satisfied.

It is also possible to arrange antennas along several axes and hence permit measuring in at several planes. By placing at least one additional pair of array antennas along an axis substantially perpendicular to the first axis and substantially perpendicular to the direction of travel of the object, a reference angle to the object in relation to the antennas may thus be determined in each of the two planes, substantially perpendicular to each other, which are formed by the object and the respective axis on which pairs of antennas are arranged. If, as an example, the object consists of a vehicle travelling on a roadway, where array antennas are arranged along a horizontal first axis at such a height above the roadway that vehicles may pass under the antennas, a substantially horizontal first plane is defined by the antennas 1, 2 and the vehicle 3. In this horizontal plane, an azimuth angle θ to the vehicle may be determined, as described, by determining the phase angle φ. By arranging array antennas along a second axis, which is perpendicular to the first axis and substantially

perpendicular to the roadway, it is made correspondingly possible to determine an angle of elevation to the vehicle, where the angle of elevation refers to the vertical second axis. With knowledge of both the azimuth angle and the angle of elevation, as viewed from the two arrays of antennas, the position of the vehicle in relation to the antennas is determined from these angles.

An alternative embodiment with connection, according to the invention, between the different part surfaces arises by arranging certain antenna elements so as to be included in two or more array antennas. The embodiment is described schematically in Figure 4 for the case of measuring in in two dimensions. In this case, the antenna 20 comprises at least three array antennas. The array antenna 21 consists of the antenna elements 24-26, 28-30 and 32-34, where 29 constitutes the phase center. The array antenna 22 consists of the antenna elements 25-27, 29-31, and 33-35, with 30 being the phase center. The array antenna 23 consists of the antenna elements 28-30, 32-34 and 36-38, with 33 being the phase center. Thus, several antenna elements are used by more than one array antenna. This is made possible by power amplification of the signals received from at least these antenna elements and thereafter by applying power division to the amplified signal. In this embodiment, the same short distance d is obtained as in the previous embodiment.

CLAIMS

1. A device for determining the position of a vehicle on a roadway by using radio waves which are emitted from the device and reflected by the vehicle and received by at least two array antennas (1, 2) arranged across the roadway, **characterized** in that the array antennas (1, 2) comprise a number of antenna elements (5-14), one of the antenna elements in the respective array antenna constituting the phase center (5, 10) of the array antennas, and wherein the antenna elements (5-14) of the array antennas are connected to one another such that the distance (d) between the phase centers (5, 10) of the array antennas (1, 2) included is smaller than half the width of an individual array antenna (1, 2).

2. A device according to claim 1, **characterized** in that the connection comprises interweaving the array antennas (1, 2) with each other in that the phase center (5, 10) of one array antenna is arranged among the antenna elements (11-14, 6-9) of another array antenna (1, 2).

3. A device according to claim 2, **characterized** in that the phase centers (5, 10) of the respective array antennas (1, 2) are placed close to each other.

4. A device according to claim 2, **characterized** in that some of the antenna elements (24-38) are at the same time connected to more than one array antenna (21, 22, 23).

5. A device according to claim 4, **characterized** in that signals obtained from antenna elements (24-38) which are utilized by more than one array antenna (21, 22, 23) undergo power amplification, followed by power division of the amplified signal on the respective array antenna (21, 22, 23).

6. A device according to any of the preceding claims, **characterized** in that an azimuth angle θ to the vehicle (3)

is determined from an antenna position where at least one pair of substantially horizontally arranged array antennas (1, 2) is arranged.

7. A device according to claim 6, **characterized** in that an angle of elevation to the vehicle (3) is determined from an antenna position where at least one pair of substantially vertically arranged array antennas is arranged.

8. A device according to claim 7, **characterized** in that the position of the vehicle in relation to the antennas is determined by means of knowledge of the azimuth angle θ and the angle of elevation.

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G01S 13/42, 13/74

A1

(11) International Publication Number: **WO 99/67655**

(43) International Publication Date: 29 December 1999 (29.12.99)

(21) International Application Number: PCT/SE99/00936

(22) International Filing Date: 31 May 1999 (31.05.99)

(30) Priority Data:
9802234-6 24 June 1998 (24.06.98) SE

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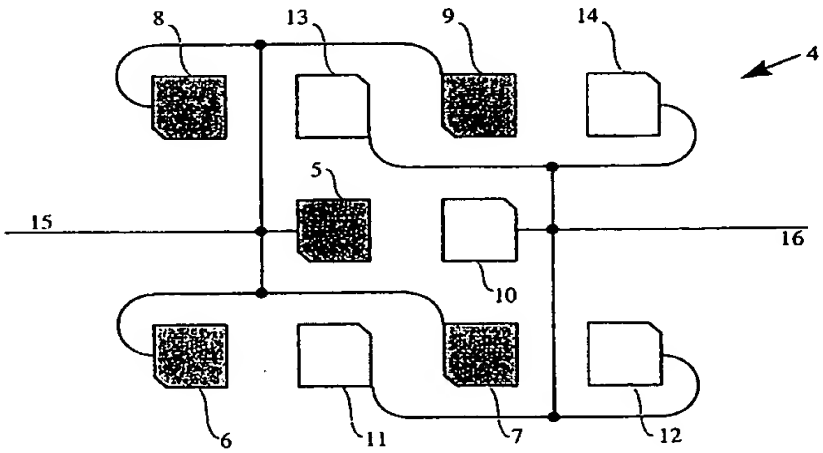
(81) Designated States: AU, BR, CN, KR, NO, SG, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.
In English translation (filed in Swedish).

(54) Title: DEVICE FOR POSITION DETERMINATION BY MEANS OF RADIO WAVES



(57) Abstract

A device for determining the position of a vehicle on a roadway by using radio waves which are emitted from the device and reflected by the vehicle and received by at least two array antennas (1, 2) arranged across the roadway, wherein the array antennas (1, 2) comprise a number of antenna elements (5–14), one of the antenna elements in the respective array antenna constituting the phase center (5, 10) of the array antennas, and wherein the antenna elements (5–14) of the array antennas are connected to one another such that the distance (d) between the phase centers (5, 10) of the array antennas (1, 2) included is smaller than half the width of an individual array antenna (1, 2).

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DEVICE FOR POSITION DETERMINATION BY MEANS OF RADIO WAVES

TECHNICAL FIELD

The invention relates to a device for position determination by means of radio waves, preferably microwaves. In particular, it relates to successive position determination of vehicles on a roadway.

BACKGROUND ART

In a method for position determination by means of radio waves, so-called measuring in, a radio signal is emitted, preferably within the microwave range, where the signal has good directivity and the property of being reflected from objects, or, alternatively, of being reemitted with a device intended therefor. The reflected signal is received with two antennas, which are arranged so as to be at a distance from each other in a plane substantially perpendicular to the direction to the object. By the distance between the antennas, a wave reflected by the object will have a longer distance of travel to one of the antennas than to the other. This difference in the distance covered gives rise to a phase difference between the received signals. From the phase difference, a reference angle to the object in relation to the antennas may be calculated in a plane which is formed by antennas and object. Such a method is described, for example, in Swedish patent application No. 8403564-1. In this way, each position of the object corresponds to a certain phase difference.

The method is shown geometrically in Figure 1. The antennas 1 and 2 are placed at a distance d from each other. The object 3, or usually a so-called transponder on this object, the position of which is to be determined, reflects the emitted wave in a direction towards the antennas 1 and 2. Because the antennas are spaced at the distance d from each other, a difference ΔL in the distance covered arises. The difference ΔL gives rise to a

phase difference $\Delta\varphi = \varphi_1 - \varphi_2$, where φ_1 and φ_2 are the phase angle for the signal received at the antennas 1 and 2, respectively. From this phase difference $\Delta\varphi$, the geometrical angle θ may be calculated, $\sin\theta \propto \Delta L \propto \Delta\varphi$.

The angle θ is thus periodically dependent on the phase difference $\Delta\varphi$, as is clear from Figure 2. This means that there is an interval outside of which the angle θ is no longer unambiguous but may correspond to more than one position. This interval is inversely dependent on the distance d, that is, the interval increases when d decreases. Thus, from this point of view, it is desired to have as small a distance d as possible to achieve a large unambiguous region for the angle θ.

To achieve good directivity in an antenna, it is composed of a plurality of antenna elements to form so-called array antennas. Such an arrangement, of course, gives the antennas a certain physical extent and thus limits the distance d downward. The distance d in Figure 1 relates, for a pair of array antennas, to the distance between the respective antenna centers.

Hence, the requirement for good directivity conflicts with the requirement for a large unambiguous region. The invention suggests a device for satisfying the requirement for good directivity while at the same time maintaining the requirement for a large unambiguous region.

SUMMARY OF THE INVENTION

The invention is directed towards achieving a small distance between the centers of at least two array antennas while still allowing a large extent for the respective array antenna in order to permit both good directivity and a large unambiguous region. This is achieved according to the aspect of the invention by interweaving antenna elements of the array antennas with

one another in such a way that the antenna centers for the array antennas are at a small mutual distance. This is achieved according to the invention by connecting the various antenna elements in the array antennas such that the central antenna elements in the respective array antenna are arranged close to one another.

BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1 and 2 relate to the basic principles of the invention and are described above as prior art, whereas Figures 3, 4 and 5 relate to one aspect of the invention.

Figure 1 is a schematic picture of a principle of measurement in which the phase difference between two signals received in antennas are analyzed for position determination of an object by angular measurement with the antennas placed at a definite distance from one another,

Figure 2 illustrates the geometrical angular deviation for the object as a function of the phase difference,

Figure 3 shows an antenna arrangement according to the invention in a frontal view,

Figure 4 shows an alternative antenna arrangement according to the invention,

Figure 5 shows a block diagram for a device for measuring in, which utilizes an antenna arrangement according to the aspect of the invention.

DESCRIPTION OF EMBODIMENTS

Figure 5 shows a device for position determination of an object which travels along a path. The device comprises an amplification and signal-processing unit 17 connected to a signal processor 18 and an antenna arrangement 4 with two array antennas 1 and 2, the array antennas being arranged along a first axis perpendicular to the direction of travel of the object. The antenna arrangement comprises two arrays of conducting surfaces, antenna elements,

according to Figure 3. The array antenna 1 is formed of the five surfaces, antenna elements, 5-9 in such a way that the antenna elements 6-9 are placed peripherally around the central antenna element 5. In the same way, array antenna 2 is formed of the central antenna element 10 and the peripheral antenna elements 11-14. Through the output conductors 15 and 16, the antenna elements within the respective array are joined together to form the two array antennas 1 and 2. By means of the arrangement described, symmetrically arranged around the central antenna elements 5 and 10, respectively, these central surfaces, in the form of antenna elements, form the phase center of the respective array antenna. The distance between these two phase centers thus constitutes the distance d in Figure 1.

The width of the antenna 1 extends from the lefthand edge of the antenna elements 6 and 8 to the righthand edge of the antenna elements 7 and 9. The width of the antenna 2 extends from the lefthand edge of the antenna elements 11 and 13 to the righthand edge of the antenna elements 12 and 14. If the antennas were placed side by side, this would mean that the distance d between the respective phase centers 5 and 10 would become at least as large as the total width of an array antenna, and in practice more since there has to be a certain distance between the outermost antenna elements in the respective array antenna 1, 2. As is clear from Figure 3, however, the distance between the phase centers is considerably smaller, which thus is achieved by interconnecting the various antenna elements, in this embodiment by allowing the array antennas to be interwoven with one another.

The principle described may be utilized also in more complicated antenna arrangements. Thus, angle measurement may be refined by placing more than two antennas in such an arrangement, that is, with the antennas arranged along the first axis. The accuracy of measurement is, of course,

improved if it is possible to form the mean value over a large number of measurement results.

Another advantage of using more than two array antennas aligned on the same axis is given by the following. If the distance d between the centers of two array antennas increases, this implies that the distance ΔL increases for each angle θ. If the distance ΔL is increased, this implies an increased phase difference $\Delta\varphi$ for each change of angle, that is, the resolution is improved. Again, this comes into conflict with the requirement for unambiguity. By arranging a plurality of array antennas in a row on the same axis, for example, three antennas designated A, B and C in the mentioned order, the described conflict may be solved. By using the measured phase difference from data obtained from antennas A and B for the unambiguity and the measured phase difference between antennas A and C for obtaining an improved resolution, both requirements may be satisfied.

It is also possible to arrange antennas along several axes and hence permit measuring in at several planes. By placing at least one additional pair of array antennas along an axis substantially perpendicular to the first axis and substantially perpendicular to the direction of travel of the object, a reference angle to the object in relation to the antennas may thus be determined in each of the two planes, substantially perpendicular to each other, which are formed by the object and the respective axis on which pairs of antennas are arranged. If, as an example, the object consists of a vehicle travelling on a roadway, where array antennas are arranged along a horizontal first axis at such a height above the roadway that vehicles may pass under the antennas, a substantially horizontal first plane is defined by the antennas 1, 2 and the vehicle 3. In this horizontal plane, an azimuth angle θ to the vehicle may be determined, as described, by determining the phase angle φ. By arranging array antennas along a second axis, which is perpendicular to the first axis and substantially

perpendicular to the roadway, it is made correspondingly possible to determine an angle of elevation to the vehicle, where the angle of elevation refers to the vertical second axis. With knowledge of both the azimuth angle and the angle of elevation, as viewed from the two arrays of antennas, the position of the vehicle in relation to the antennas is determined from these angles.

An alternative embodiment with connection, according to the invention, between the different part surfaces arises by arranging certain antenna elements so as to be included in two or more array antennas. The embodiment is described schematically in Figure 4 for the case of measuring in in two dimensions. In this case, the antenna 20 comprises at least three array antennas. The array antenna 21 consists of the antenna elements 24-26, 28-30 and 32-34, where 29 constitutes the phase center. The array antenna 22 consists of the antenna elements 25-27, 29-31, and 33-35, with 30 being the phase center. The array antenna 23 consists of the antenna elements 28-30, 32-34 and 36-38, with 33 being the phase center. Thus, several antenna elements are used by more than one array antenna. This is made possible by power amplification of the signals received from at least these antenna elements and thereafter by applying power division to the amplified signal. In this embodiment, the same short distance d is obtained as in the previous embodiment.

CLAIMS

1. A device for determining the position of a vehicle on a roadway by using radio waves which are emitted from the device and reflected by the vehicle and received by at least two array antennas (1, 2) arranged across the roadway, **characterized** in that the array antennas (1, 2) comprise a number of antenna elements (5-14), one of the antenna elements in the respective array antenna constituting the phase center (5, 10) of the array antennas, and wherein the antenna elements (5-14) of the array antennas are connected to one another such that the distance (d) between the phase centers (5, 10) of the array antennas (1, 2) included is smaller than half the width of an individual array antenna (1, 2).

2. A device according to claim 1, **characterized** in that the connection comprises interweaving the array antennas (1, 2) with each other in that the phase center (5, 10) of one array antenna is arranged among the antenna elements (11-14, 6-9) of another array antenna (1, 2).

3. A device according to claim 2, **characterized** in that the phase centers (5, 10) of the respective array antennas (1, 2) are placed close to each other.

4. A device according to claim 2, **characterized** in that some of the antenna elements (24-38) are at the same time connected to more than one array antenna (21, 22, 23).

5. A device according to claim 4, **characterized** in that signals obtained from antenna elements (24-38) which are utilized by more than one array antenna (21, 22, 23) undergo power amplification, followed by power division of the amplified signal on the respective array antenna (21, 22, 23).

6. A device according to any of the preceding claims, **characterized** in that an azimuth angle θ to the vehicle (3)

is determined from an antenna position where at least one pair of substantially horizontally arranged array antennas (1, 2) is arranged.

7. A device according to claim 6, **characterized** in that an angle of elevation to the vehicle (3) is determined from an antenna position where at least one pair of substantially vertically arranged array antennas is arranged.

8. A device according to claim 7, **characterized** in that the position of the vehicle in relation to the antennas is determined by means of knowledge of the azimuth angle θ and the angle of elevation.

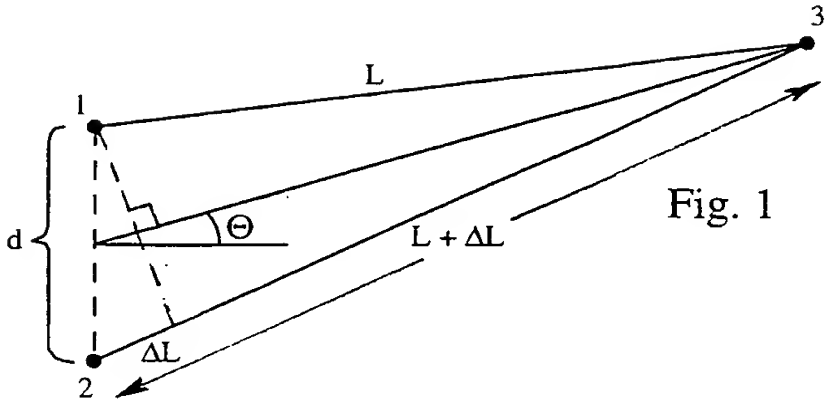


Fig. 1

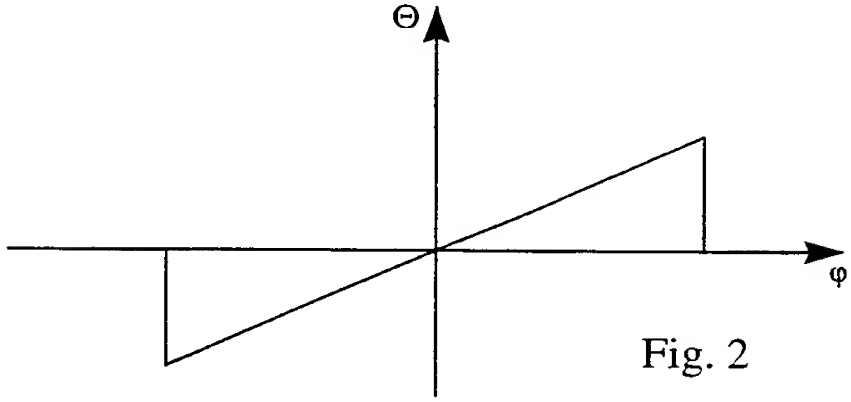


Fig. 2

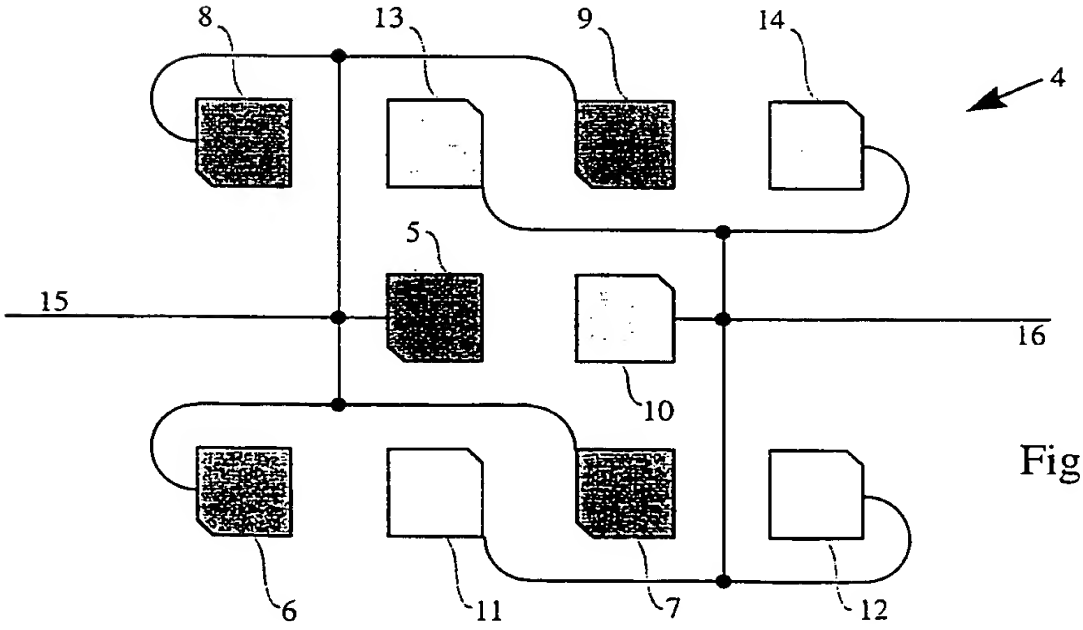


Fig. 3

Fig. 4

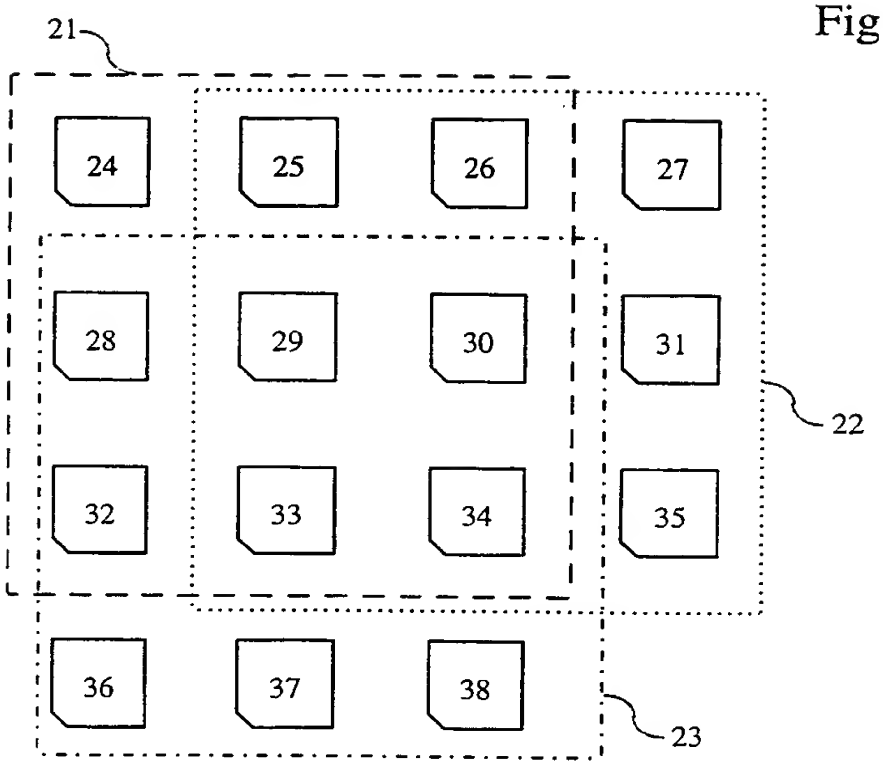
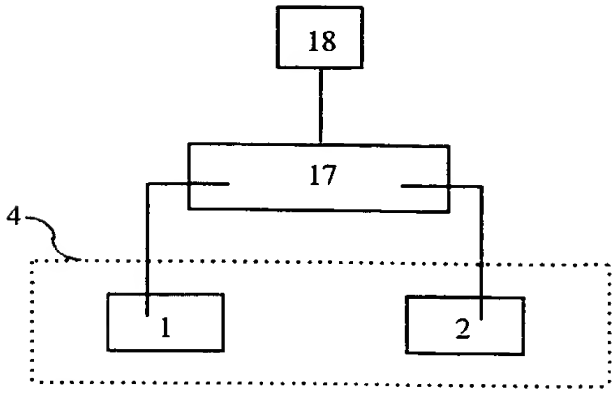


Fig. 5



INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 99/00936

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G01S 13/42, G01S 13/74
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 8600716 A1 (STIFTELSEN INSTITUTET FÖR MIKROVÅGSTEKNIK VID TEKNISKA HÖGSKOLAN I STOCKHOLM), 30 January 1986 (30.01.86), figures 1, 4, abstract --	1-8
Y	WO 9219021 A1 (THE COMMONWEALTH OF AUSTRALIA), 29 October 1992 (29.10.92), page 5, line 20 - line 33, figure 3 --	1-3,6-8
Y	US 5546095 A (ALFRED R. LOPEZ), 13 August 1996 (13.08.96), column 3, line 35 - line 45; column 4, line 15 - line 55, figures 1,2 -- --------	4-5

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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WO 8600716 A1	30/01/86	AT 64212 T	15/06/91
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		US 4728955 A	01/03/88
WO 9219021 A1	29/10/92	AU 653836 B	13/10/94
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REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

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International Filing Date

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Applicant's or agent's file reference *(if desired) (12 characters maximum)* 884 /85663

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State *(that is, country)* of residence: Sweden

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

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This person is:

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☒ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

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Box No. VI PRIORITY CLAIM ☐ Further priority claims are indicated in the Supplemental Box.

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item (2)				
item (3)				

☒ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office)* identified above as item(s): (1)

** Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.*

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used)*: ISA /

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority)*:
Date *(day/month/year)* Number Country *(or regional Office)*

Box No. VIII CHECK LIST; LANGUAGE OF FILING

This international application contains the following **number of sheets**:

request	:	3
description (excluding sequence listing part)	:	7
claims	:	2
abstract	:	1
drawings	:	2
sequence listing part of description	:	
Total number of sheets	:	15

This international application is **accompanied by** the item(s) marked below:

1. ☐ fee calculation sheet
2. ☐ separate signed power of attorney
3. ☒ copy of general power of attorney; reference number, if any:
4. ☐ statement explaining lack of signature
5. ☐ priority document(s) identified in Box No. VI as item(s):
6. ☐ translation of international application into (language):
7. ☐ separate indications concerning deposited microorganism or other biological material
8. ☐ nucleotide and/or amino acid sequence listing in computer readable form
9. ☐ other *(specify)*:

Figure of the drawings which should accompany the abstract:

Language of filing of the international application: Swedish

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

Linköping, May 28, 1999

Jan-Erik Lundmark

For receiving Office use only

1. Date of actual receipt of the purported international application:	2. Drawings: ☐ received: ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:	
4. Date of timely receipt of the required corrections under PCT Article 11(2):	
5. International Searching Authority (if two or more are competent): ISA /	6. ☐ Transmittal of search copy delayed until search fee is paid.

For International Bureau use only

Date of receipt of the record copy by the International Bureau: